



Research Article

Surface Water Comparative Assessment of Physicochemical Properties of Channels Effluent and New Gusau Reservoir, Zamfara State, Nigeria

<sup>1</sup>Sani, Z. R\* and <sup>2</sup>Rabiu, S

<sup>1</sup>Department of Biological Sciences, Federal University Gusau, Zamfara State Nigeria

<sup>2</sup>Department of Biological Sciences, Bayero University, Kano, Nigeria

\*Corresponding Author: [rszurme@gmail.com](mailto:rszurme@gmail.com)

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ABSTRACT

This study was undertaken from February 2019 to July 2020 to assess the surface water physicochemical quality of the New Gusau reservoir and its impact on effluent channels of Yar Dantse (YDS), Yar Dole (YDL), and Yar Rumfa (YRF), which empty their content into New Gusau Reservoir (NGR). Samples were collected using purposive sampling from nine sampling points. Insitu measurement of pH, temperature (°C), Conductivity (EC), Total dissolved solid (TDS), Dissolved oxygen (DO), and Biological oxygen demand (BOD) were conducted using a Multifunctional meter. The result was analyzed using the standard procedure for examination of water and wastewater system and one-way ANOVA technique with a significant difference set at  $p < 0.05$ . The result shows mean seasonal variations in surface water parameters; The pH varies from  $6.89 \pm 0.086$  to  $6.97 \pm 0.073$ , temperature (°C) ranges from  $27.26 \pm 0.184$  to  $27.78 \pm 0.234$  across the effluent channels, EC fluctuated between  $257.35 \pm 31.475$  and  $475.35 \pm 56.595$ , TDS in parts per million (ppm) ranges from  $134.90 \pm 13.518$  to  $237.61 \pm 27.467$ , while DO varies from  $6.18 \pm 0.102$  to  $6.85 \pm 0.042$  and finally, BOD ranges between  $2.49 \pm 0.062$  to  $3.20 \pm 0.161$  in YDS, YDL, YRF, and NGR respectively. The result of all selected physicochemical parameters revealed significant ( $p < 0.05$ ) seasonal sites variations except the pH and temperature which shows otherwise. Furthermore, all the parameters investigated were within the WHO acceptable limits except for EC. Therefore, the New Gusau Reservoir (NGR) is not polluted based on this finding.

Corresponding author: Sani, Z. R, Email: [rszurme@gmail.com](mailto:rszurme@gmail.com)  
Department of Biological Sciences, Federal University Gusau, Nigeria

## INTRODUCTION

Water is a veritable tool of natural origin that serves useful purposes to man. The earth's surface is made up of 70% water, which includes rivers, lakes, reservoirs, streams, seas, oceans, and groundwater (Mtethia *et al.*, 2008). All these forms are very important in the life cycle (Adakole, 1995; Arimieari *et al.*, 2014). The discharge of effluent has prolonged harmful effects not only to the aquatic life forms but also destroys the cycle of self - purification characteristic and biological nature of receiving water body (Simenonov *et al.*, 2011). These contaminated and degraded surface water bodies are not useful for agricultural, domestic, industrial, recreation, and other purposes (Ajibade *et al.*, 2008; O-yang, 1990). Unclassified chemicals considered harmful and unhealthy (Jarvie *et al.*, 2018) are in regular use in the textile hub. The effluent from these small units is characterized by a high concentration of biochemical oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), chloride (Cl), carbonate ( $\text{CaCO}_3$ ), heavy metals (Fe, Pb, Cr, Zn, Cd, Cu, etc.) and carcinogenic dye ingredients (Mtethia *et al.*, 2008). Despite the fact that water contamination or pollution is a universal problem, the nature of contaminant differs, depending on the developmental stage of the area under investigation (Adefemi *et al.* 2007) Areas or countries with a fast-growing population which do not have proper waste managerial practice or system are more likely to produce wastes which constitute pollution to the environment than those countries with slower population growth rate, that also practice proper waste management control (WHO, 2003).

Reservoirs or man-made lakes are impoundments created largely by humans by the damming of river valleys. Humans have created artificial lakes by damming for at least 4000 years (Jabbi *et al.*,

2018). It is only recently that the damming activities have become highly significant for the purpose of flood control, irrigation, and provision of power and water supplies for urban, ever-growing populations (Tanimu, 2015). Most of the water bodies in the developing world are the endpoints of effluents discharged from industries, new Gusau reservoir was not left behind, it received untreated effluents from industries such as Zamfara textile industry, Gusau oil mill limited, Dan Maikyau ginnery, Gusau hotel, Gusau sweet factory, Yar dole chicken abattoir, Hamdala block and quarry industry and effluent discharge from various houses in Gusau metropolis. Other sources of contamination include farmland, mechanic garage, painters, welding stations, filling stations, oil spills, electric power stations, car wash points, etc. The reservoir received a large deposit of effluent with a lot of garbage through Yar Dantse, Yar Dole, and Yar Rumfa waterways; hence the water quality of this reservoir has been tremendously affected as a result of the human activities and it's the main source of the state capital water supply and neighboring villages.

Surface Water is considered for assessment to know the extent of contamination by various pollutants which are either intermittently or continuously discharged from various point and nonpoint sources to the receiving new Gusau reservoir. Hence to evaluate such seasonal, and annual physico-chemical variation in surface water, four sampling sites (Yar Dantse, Yar Dole, Yar Rumfa, and New Gusau reservoir) were selected for the current study.

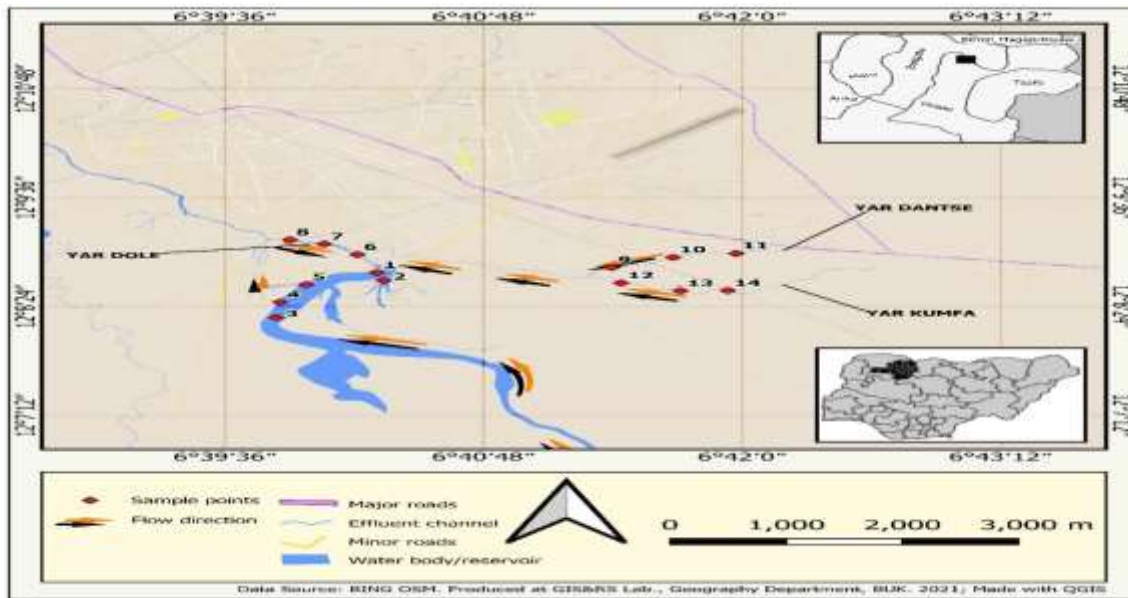
## MATERIAL AND METHODS

### Study area

The reservoir is located in Gusau Local Government Area of Zamfara State, (Figure 1), Nigeria, located between latitude  $12^{\circ}17'02.40''$  N

and longitude  $6^{\circ}39'50.83''$   $6^{\circ}66'41.20''$  E, and occupies an area of 3,364km (1,298.8sqmi). Gusau Local Government had a population of 383,162 people (NPC, 2006). The new Gusau reservoir is gated in the channel of Sokoto River; it is made up of a mass concrete weir surmounted

by five steel gates which is operated by electric motors and bar-link chains with provision for emergency manual operation. Concrete walls are also provided at each end of the reservoir, to protect the ends of the reservoir from erosion (Jabbi *et al.*, 2018).



**Figure 1:** Map of the Study Area Showing channels and Gusau reservoir sampling points

### Determination of Surface Water Physico-chemical Parameters

Surface water physico-chemical parameters viz; temperature, pH, total dissolved solids, electrical conductivity, dissolved oxygen, biological oxygen demand, were determined by using methods described by UNEP, (2004); APHA (2005), and Panday *et al.*, (2005). Surface water was collected by immersion of the laboratory cleaned sample bottle below the surface of a surface water body and closed the bottle while inside the water. The following parameters were measured in situ using the Multifunction pH/EC/Temp/TDS metre model/EZ9908 water quality checker: pH, Temperature, Total dissolved solids, conductivity, Dissolved Oxygen, and Biological Oxygen demand were

determined. The metre was allowed to equilibrate before the readings were recorded, except BOD<sub>5</sub> where water samples collected were kept in the icebox to maintain them at a temperature below 4°C during the transfer from the field to the laboratory within 24 hours. Biological oxygen demand (BOD<sub>5</sub>), was determined by taking initial DO and final DO using an Oxygen meter, after five days incubation at room temperature as described in APHA 2005. Dissolved oxygen (DO) was measured on-site using an Oxygen meter (Model: DO 5510 M.R.C.) according to the manufacturer's guide. The electrode of calibrated meter was dip into the reservoir water, gently stirring the water with the probe, and then allowed to equilibrate before the value was recorded in mg/l.

### Data Analysis

The results were presented as mean  $\pm$  standard error of the mean. One-way analysis of variance (ANOVA) was used to compare the mean at the significant value of ( $p < 0.05$ ) using IBM SPSS Statistics software version 23.0 Microsoft office excel, 2012 was used for the construction of graphs/charts.

### RESULTS AND DISCUSSION

The results of this research showed a wide range of variation for all the sampling sites (channels effluent and new Gusau reservoir). Six (6) physicochemical parameters viz; pH, temperature, electrical conductivity, total dissolved solids, dissolved oxygen, and biochemical oxygen demand, were monitored.

The levels of these parameters are indicators of water quality which was compared with known standards to ascertain the pollution status. The mean sites, annual and seasonal variation of the physico-chemical parameters for the period of these studies are presented in Table 1, 3.2, and 3.3. Variation of these parameters due to contribution of channels effluent and pollution (agricultural runoff viz; application of fertilizers, insecticide, and herbicide), mixed farming, deforestation along with other climatic factors such as wind and rainfall and their effects on the reservoir were also considered (Ho, 2003). Ajibade *et al.*, (2008) and Mustapha (2008) reported that the activities in the catchment areas are the most prominent determinants of water quality in an aquatic system.

**Table 1:** Composite Sites Physico-Chemical Parameters Recorded from February 2019 - July 2020

Parameters/ site	Yar Dantse	Yar Dole	Yar Rumfa	NGR	P- Value	NSD WQ	WHO
<b>pH</b>	6.90 <sup>a</sup> $\pm$ .085	6.97 <sup>a</sup> $\pm$ .073	6.89 <sup>a</sup> $\pm$ .086	6.95 <sup>a</sup> $\pm$ .035	.879	6.5- 8.5	8.5
<b>Range</b>	5.67-7.64	6.00-7.73	5.79-8.18	6.62-8.6			
<b>Temp. (°C)</b>	27.62 <sup>a</sup> $\pm$ .206	27.78 <sup>a</sup> $\pm$ .234	27.26 <sup>a</sup> $\pm$ .184	27.76 <sup>a</sup> $\pm$ .112	.282	30	30
<b>Range</b>	24.30-31.00	24.20-31.00	24.20-30	24.10-30			
<b>EC (<math>\mu</math>S cm<sup>-1</sup>)</b>	257.35 <sup>b</sup> $\pm$ 31.47	475.35 <sup>a</sup> $\pm$ 56.5	405.09 <sup>a</sup> $\pm$ 39.810	418.95 <sup>a</sup> $\pm$ 27.234	.029	1000	250
	5	95					
<b>Range</b>	77-939	57-1701	63-923	57-2330			
<b>TDS (ppm)</b>	134.90 <sup>b</sup> $\pm$ 13.51	229.29 <sup>a</sup> $\pm$ 27.6	237.61 <sup>a</sup> $\pm$ 27.467	183.82 <sup>a</sup> $\pm$ 11.993	.015	500	1000
	8	81					
<b>Range</b>	39-471	40-826	38-754	39-1170			
<b>DO (mg/l)</b>	6.75 <sup>c</sup> $\pm$ .085	6.18 <sup>c</sup> $\pm$ .102	6.48 <sup>b</sup> $\pm$ .083	6.85 <sup>a</sup> $\pm$ .042	.000	10	10
<b>Range</b>	4.60-7.71	4.90-7.80	4.90-7.76	5.60-8.54			
<b>BOD<sub>5</sub> (mg/l)</b>	3.13 <sup>a</sup> $\pm$ .142	2.54 <sup>b</sup> $\pm$ .052	2.49 <sup>b</sup> $\pm$ .062	3.20 <sup>a</sup> $\pm$ .161	.000	10	10
<b>Range</b>	1.90-5.07	1.67-3.23	1.25-3.13	1.54-5.90			

**Note:** Result presented as Mean  $\pm$  SE and Range Values; Means in the same row with different superscripts are significantly different at  $p < 0.05$  levels. NSDWQ = Nigerian Standard for Drinking Water Quality 2007; WHO = World Health Organization 2017

The physicochemical parameters result obtained from the analysis of water samples of different sampling sites were presented in Table 1. The average pH value was from 5.67 to 7.64 with a mean value of  $6.90 \pm 0.085$  at Yar Dantse sampling site, at Yar Dole with a mean value of  $6.97 \pm 0.073$  and a range of 6.00-7.73, at site 3 (Yar Rumfa), it has a mean of  $6.89 \pm 0.086$  and 5.79-8.18 range and that of new Gusau reservoir, has to mean value of  $6.95 \pm 0.035$  and range of 6.62-8.60. Based on the given facts pH of the new Gusau reservoir is suitable for fish at present time. The present results obtained for pH are similar to the results obtained by Adefemi *et al.* (2007); Adefemi and Awokunmi (2010). The pH below 4.8 and above 9.2 are deleterious for aquatic organisms, especially fish. Asaolu (1997) also reported similar results in water samples from Ondo State coastal water. Analysis of variance (Table 2 and 3.3) shows no significant variation between the two seasons, sites, and years ( $p > 0.05$ ). In the Yar Dole site the mean temperature value was  $27.78 \pm 0.234$ , at the Yar Dantse site its  $27.62 \pm 0.206$ , at Yar Rumfa and the new Gusau reservoir, the mean values are  $27.26 \pm 0.184$  and  $27.76 \pm 0.112$ , respectively. Analysis of variance of sampling site and season temperatures at 0.05 probability level showed no significant ( $P > 0.05$ ) difference ( $p = 0.282$ ). The temperature variations in the lake were normal ( $29.0^{\circ}\text{C}$ ) for metabolic activities of organisms such as fish as reported by Yang (2018) will not affect the water quality for drinking or fish production. The water temperature recorded during this study, when compared with other tropical water was within acceptable ranges for aquatic life in tropical ecosystems. Ajibade *et al.*, (2008) found the surface water temperature for major rivers of Kainji Lake National park, Nigeria range between  $22.6 - 31^{\circ}\text{C}$  while Devange *et al.*, (2013)

observed a mean temperature range of  $23.2 - 25.20^{\circ}\text{C}$  in Kisian and Kisat Rivers in Lake Victoria drainage basin, Kenya.

Electrical conductivity is a function of the types and amount of substances that are dissolved in water. Electrical conductivity and total dissolved solid were found to be significantly lower in the rainy season (Table 3.2 and Table 3); this may be due to dilution of the water as the volume increases and continues discharge of the water to maintain a certain capacity/volume of the reservoir in the prevention of flood, as the reservoir is gated. This agrees with the findings of Devangee *et al.*, (2013) Magami *et al.*, (2014), and Balarabe (1989) in their studies on Shagari Reservoir, Kankariya, Vastrapur, Malav, and Chandola Lake India, River Kubbani and Makwaye Lake, Zaria respectively. High levels of TDS in surface waters can lead to eutrophication in the long term (Mtethia *et al.*, 2008). But for domestic use, water preferably has a TDS of less than 500 ppm. Water used in agriculture must have a TDS of less than 1200 ppm so that fragile crops are not damaged (Balarabe 1989). For industry, and especially for the electronics industry, pure water is needed (Navarro *et al.*, 2001). The result obtained in this research (Table 1) were within the maximum permissible limit (MPL) sets by NSDWQ (2007) and WHO (2008). In relation to electrical conductivity and total dissolved solid the water is considered safe for human consumption.

The monthly mean temporal variations in dissolved oxygen are presented in Table 1 In Gusau reservoir the DO is ( $6.85 \pm 0.042$  mg/l) while the fluctuation in Yar Dantse is ( $6.75 \pm 0.085$  mg/l), Yar Dole is ( $6.18 \pm 0.102$  mg/l) and Yar Rumfa is ( $6.48 \pm 0.083$  mg/l), these findings are in agreement with Magami *et al.*, (2014) and Adakole (1995) the result showed significant difference (0.00) at ( $P < 0.05$ ) among the season, years and sites (Table 3). Depletion of DO in water bodies is most frequent as a result of certain forms of water

pollution (Srivastava *et al.*, 2009). The DO for the rainy season is significantly higher and this may be due to seasonal changes in air temperature resulting from the harmattan (Adefemi and Awokunmi 2010) This result agrees with the findings of Devangee *et al.*, (2013) in their studies

on Kankariya, Vastrapur, Malav, and Chandola Lake India. Similarly, APHA (2005) also explained that a dissolved oxygen concentration above 5 mg/l is suitable for the support of diverse biota.

**Table 2:** Seasonal Variation in Surface Water Physico Chemical Parameters for Composite Sites Recorded from February 2019 - July 2020.

Parameters/ site Season	Yar Dantse	Yar Dole	Yar Rumfa	NGR	P- Value	NSDWQ	WHO
<b>PH</b>							
Rainy	7.12 <sup>a</sup> ±.080	7.13 <sup>a</sup> ±.084	7.04 <sup>a</sup> ±.102	7.02 <sup>a</sup> ±.040	.586	6.5-8.5	8.5
Dry	6.64 <sup>a</sup> ±.150	6.76 <sup>a</sup> ±.114	6.70 <sup>a</sup> ±.676	6.85 <sup>a</sup> ±.059	.422		
<b>Temperature (°C)</b>							
Rainy	27.75 <sup>a</sup> ±.206	27.83 <sup>a</sup> ±.249	27.46 <sup>a</sup> ±.177	28.13 <sup>a</sup> ±.121	.067	30	30
Dry	27.47 <sup>a</sup> ±.388	27.72 <sup>a</sup> ±.432	27.02 <sup>a</sup> ±.350	27.28 <sup>a</sup> ±.194	.666		
<b>EC (µS/cm)</b>							
Rainy	244.30 <sup>a</sup> ±44.008	436.87 <sup>a</sup> ±90.688	376.90 <sup>a</sup> ±57.305	314.59 <sup>a</sup> ±33.595	.240	1000	250
Dry	273.42 <sup>b</sup> ±45.428	523.46 <sup>a</sup> ±58.850	440.33 <sup>b</sup> ±54.262	549.41 <sup>a</sup> ±41.815	.018		
<b>TDS (ppm)</b>							
Rainy	124.53 <sup>b</sup> ±21.991	215.90 <sup>ab</sup> ±43.810	260.70 <sup>a</sup> ±45.073	168.32 <sup>a</sup> ±17.566	.057	500	1000
Dry	147.86 <sup>b</sup> ±13.453	246.04 <sup>a</sup> ±30.430	208.75 <sup>b</sup> ±25.387	203.21 <sup>b</sup> ±15.587	.175		
<b>DO (mg/l)</b>							
Rainy	6.89 <sup>a</sup> ±.106	6.23 <sup>b</sup> ±.145	6.49 <sup>b</sup> ±.123	6.96 <sup>a</sup> ±.049	.000	10	
Dry	6.58 <sup>a</sup> ±.132	6.13 <sup>b</sup> ±.145	6.47 <sup>b</sup> ±.110	6.71 <sup>a</sup> ±.071	.005		
<b>BOD<sub>5</sub> (mg/l)</b>							
Rainy	3.21 <sup>a</sup> ±.209	2.47 <sup>b</sup> ±.069	2.51 <sup>b</sup> ±.059	2.89 <sup>a</sup> ±.069	.000	10	
Dry	3.02 <sup>a</sup> ±.189	2.63 <sup>b</sup> ±.076	2.47 <sup>b</sup> ±.118	3.14 <sup>a</sup> ±.106	.008		

Note: The result presented as Mean ±SE and range Values; Means in the same row with different superscripts are significantly different at p < 0.05 levels. NSDWQ =Nigerian Standard for Drinking Water Quality 2007; WHO= World Health Organization 2017

Biochemical Oxygen Demand (BOD<sub>5</sub>) and Chemical Oxygen Demand (COD) are two common. Measures of water quality are used to gauge the degree of organic matter pollution of an aquatic system (Sangodoin, 1991). BOD is a measure of the amount of oxygen removed from aquatic environments by aerobic microorganisms during the breakdown of organic substances (Jabbi, *et al.*, 2018). The result in Yar Dantse showed 3.13±.142 mg/l, Yar Dole 2.54±.052mg/l, Yar Rumfa 2.49±.062 mg/l and NGR 3.20±.161mg/l. High values of BOD

exceeding (WHO and UNESCO, 2003) standards were also observed in effluents from Britania and Hwan Sung Fish. Biological oxygen demand concentration was observed to be higher in the rainy season (Table 2), which could be due to an increase in water level. The variations between seasons were significant; this could be due to the inflow of organic pollutants along with surface runoff. This agrees with the findings of Tanimu (2015) and Hassan *et al.*, (2014) in their studies on Tudun Wada-Makera Drain and River Kaduna and Hussainiya River, respectively.

**Table 3:** Mean  $\pm$ SE Values and Annual Variation in Surface Water Physico Chemical Parameters for Composite Sites Recorded from February, 2019 - July, 2020.

Parameters/ site YEAR	Yar Dantse	Yar Dole	Yar Rumfa	NGR	P- Value	NSDWQ	WHO
<b>pH</b>						6.5-8.5	8.5
<b>Year 1</b>	6.83 <sup>a</sup> $\pm$ .109	7.06 <sup>a</sup> $\pm$ .099	6.91 <sup>a</sup> $\pm$ .119	6.85 <sup>a</sup> $\pm$ .035	.205		
<b>Year 2</b>	6.98 <sup>a</sup> $\pm$ .132	6.88 <sup>a</sup> $\pm$ .106	6.87 <sup>a</sup> $\pm$ .125	7.04 <sup>a</sup> $\pm$ .059	.496		
<b>Temperature (°C)</b>						30	30
<b>Year 1</b>	28.27 <sup>a</sup> $\pm$ .275	28.01 <sup>a</sup> $\pm$ .267	27.14 <sup>b</sup> $\pm$ .184	28.44 <sup>a</sup> $\pm$ .164	.005		
<b>Year 2</b>	26.98 <sup>a</sup> $\pm$ .255	27.55 <sup>a</sup> $\pm$ .386	27.38 <sup>a</sup> $\pm$ .322	27.07 <sup>a</sup> $\pm$ .129	.407		
<b>EC (<math>\mu</math>S/cm)</b>						1000	250
<b>Year 1</b>	285.11 <sup>a</sup> $\pm$ 61.256	247.92 <sup>a</sup> $\pm$ 51.239	255.74 <sup>a</sup> $\pm$ 52.582	428.52 <sup>a</sup> $\pm$ 43.827	.067		
<b>Year 2</b>	229.59 <sup>c</sup> $\pm$ 15.074	702.77 <sup>a</sup> $\pm$ 80.338	554.44 <sup>b</sup> $\pm$ 44.505	409.38 <sup>b</sup> $\pm$ 32.491	.000		
<b>TDS (ppm)</b>						500	1000
<b>Year 1</b>	133.88 <sup>a</sup> $\pm$ 25.553	133.85 <sup>a</sup> $\pm$ 30.178	129.00 <sup>a</sup> $\pm$ 25.721	214.12 <sup>a</sup> $\pm$ 21.837	.073		
<b>Year 2</b>	135.92 <sup>b</sup> $\pm$ 9.948	324.74 <sup>a</sup> $\pm$ 38.892	346.22 <sup>a</sup> $\pm$ 38.818	153.53 <sup>b</sup> $\pm$ 9.324	.000		
<b>DO (mg/l)</b>						10	
<b>Year 1</b>	6.47 <sup>b</sup> $\pm$ .124	6.34 <sup>b</sup> $\pm$ .167	6.63 <sup>ab</sup> $\pm$ .124	6.87 <sup>a</sup> $\pm$ .060	.001		
<b>Year 2</b>	7.04 <sup>a</sup> $\pm$ .090	6.03 <sup>b</sup> $\pm$ .115	6.33 <sup>b</sup> $\pm$ .105	6.83 <sup>a</sup> $\pm$ .060	.000		
<b>BOD<sub>5</sub> (mg/l)</b>						10	
<b>Year 1</b>	2.44 <sup>a</sup> $\pm$ .042	2.46 <sup>a</sup> $\pm$ .045	2.20 <sup>b</sup> $\pm$ .071	2.37 <sup>a</sup> $\pm$ .029	.020		
<b>Year 2</b>	3.81 <sup>a</sup> $\pm$ .212	2.62 <sup>b</sup> $\pm$ .092	2.78 <sup>b</sup> $\pm$ .064	3.63 <sup>b</sup> $\pm$ .090	.000		

**Note:** Means in same row with different superscripts are significantly different at  $p < 0.05$  levels. NSDWQ =Nigerian Standard for Drinking Water Quality 2007; WHO= World Health Organization 2017

## CONCLUSION

The results revealed a highly significant seasonal variation in TDS, EC, BOD, and DO parameters with the exception of pH and Temperature which showed no significant annual, sites, and season variations. The findings also indicated that EC and TDS of channels effluent are high than that of the receiving new Gusau reservoir. Although all

observed parameters fall within the recommended range set by the World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ), therefore the water is of good quality for human consumption and to support aquatic life.

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